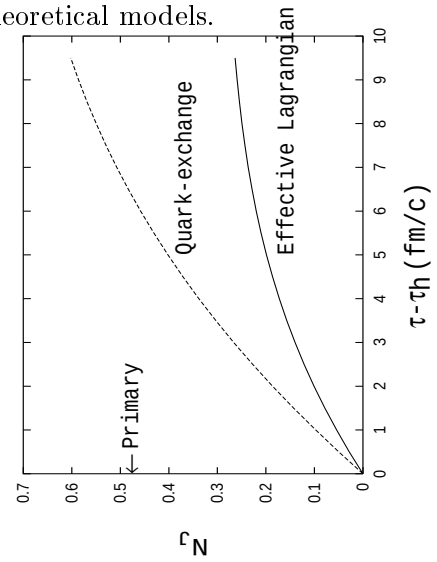
Charmonium production from the hadronic phase *

C. M. Ko[†]*X. F. Zhang*[†] *B. Zhang*[†] *and X. N. Wang*

One of the signals proposed for identifying the existence of a quark-gluon plasma in ultra-relativistic heavy-ion collisions is the suppression of J/ψ production compared to that expected from the superposition of nucleon-nucleon collisions. According to Matsui and Satz, if a quark-gluon plasma is created in heavy-ion collisions, J/ψ's produced from initial nucleon-nucleon interactions will dissociate as a result of Debye screening and vanishing string tension between c and $\bar{c}$. Therefore, J/ψ suppression at RHIC and LHC is considered as one of the most prominent signals for the quark-gluon plasma.

But J/ψ can be regenerated from the hadronic matter after the phase transition of the quark-gluon plasma. Such an effect has been shown to be important for hadrons made of strange quarks. In hadronic matter, J/ψ can be produced from the interactions of charm mesons in reactions such as $D\bar{D}^*, D^*\bar{D}, D^*\bar{D}^* \to J/\psi\pi$ and $D\bar{D}, D\bar{D}^*, D^*\bar{D}, D^*\bar{D}^* \to J/\psi\rho$. These reactions are apparently unimportant at SPS energies but may become significant at RHIC and LHC since charm production in nucleon-nucleon interaction increases with center-of-mass energy while the J/ψ to $c\bar{c}$ ratio remains essentially at a constant value of $\sim 2.5 \times 10^{-2}$ [**?**]. Furthermore, most these reactions are exothermic as $2m_D \sim 3.73$ GeV/c^2, $m_D + m^*_{\bar{D}} \sim 3.87$ GeV/c^2 and $m_{D^*} + m_{\bar{D}^*} \sim 4.01$ GeV/c^2 while $m_{J/\psi}+m_\pi \sim 3.15$ GeV/c^2 and $m_{J/\psi}+m_\rho \sim 3.87$ GeV/c^2, it is thus more likely that J/ψ's produced from the hadronic matter will survive and be detected in experiments. If this is the case, then the final number of J/ψ may be comparable to or even larger than that of primary J/ψ's which are dissociated in the quark-gluon plasma, leading instead to an absence of J/ψ suppression or even an enhanced J/ψ production. In this, we make an estimate of J/ψ production from the hadron gas formed in heavy-ion collisions at RHIC and LHC energies.

Using the initial conditions determined from the HIJING parton model and the cross section given by the nonperturbative quark-exchange model, we found that the hadronic production of J/ψ is negligible effect at RHIC, but it becomes important at LHC as a result of the appreciable number of D and $\bar{D}$ mesons in the hadron gas. We have found that the number of J/ψ produced from this reaction at LHC is more than that produced from initial primary collisions, which are either absorbed by nucleons or dissociated in the quark-gluon plasma formed in the collisions. Since using the J/ψ and ψ' yields as signals for the quark-gluon plasma at LHC requires a good understanding of their production from the hadron gas, it is important to have a better determination of the J/ψ production and absorption cross section from both experiments and theoretical models.



Time evolution of the abundance of J/ψ from Au+Au collisions at LHC using cross sections from the effective Lagrangian and the quark-exchange model. The initial J/ψ number is denoted by the arrow on the left.

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[†]Cyclotron Institute and Physics Department, Texas A&M University, College Station, Texas 77843